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INDUCTIVE E.S.O. MODEL EVOLUTION

1 - TOWARDS A VIABLE INFERENCE MODEL OF RESILIENCE DYNAMICS

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Keywords**:** Territorial resilience, sustainable capital, inductive model, viability kernel, sustainability convergence.

Abstract

In this paper, we will present the last evolution of the Territorial Intelligence (TI) networking vulnerability model. To introduce it, we'll first describe a well-known late 80's model of socio-economic crack-up, known as "Silent Weapons for Quiet Wars", constituted by three passive components as potential energy, kinetic energy, and energy dissipation. To extend this model to social and ecological sustainability pillars, we propose to present the E(Economic)-S(Social)-O(Organic) IT-collaborative model, based on the three sustainability capitals. Goal of this model is the developement system viability computation, which related "Viability theory" computational framework is able to define sustainability constraints of action politics, in order to propose requirements for resilience processing of a territorial challenge.

Résumé

Dans cet article, nous proposons une lecture de la résilience territoriale à travers le prisme du "modèle inductif de la vulnérabilité", dernière mouture du modèle collaboratif E.S.O. (Economic Social and Organic) produit au sein du réseau Intelligence Territoriale (IT). Inspiré du modèle dit du "Silent Weapon", encore appelé "modèle E" (E-model), il propose une analogie simple des éléments conceptuels utilisés dans la mécanique et l'électronique, à savoir l'énergie potentielle, l'énergie cinétique et l'énergie dissipative. En faisant l'hypothèse que ces théories mathématiques développées dans le cadre de l'étude des systèmes énergétiques ont la faculté d'être applicables à d'autres systèmes, à savoir les systèmes sociaux, économiques et écologiques du développement humain, ce modèle associe les trois capitals correspondants aux aux trois piliers de la durabilité. La théorie de la viabilité permet alors de définir l'ensemble des politiques d'action qui permettent au système de rester dans l'ensemble des contraintes de durabilité, et donc de proposer des solutions de résilience pour une situation territoriale donnée.

1. Introduction

"Resilience" is a physical term which achieved significance in psychology (Cyrulnik 1999) and then in a wide variety of fields, namely ecology, sociology and economy. As a physical analogy, resilience refers to the property of a system for its state variables to return to their

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equilibrium values after a disturbance. From an ecological perspective, resilience is defined as: "... the capacity of a system to absorb disturbance and still retain its basic function and structure." (Walter & Salt, 2006). With regard to social systems, concepts and characteristics of resilient communities have been developped within different perspectives: "... the intentional action to enhance the personal and collective capacity of its citizens and institutions to respond to and influence the course of social and economic change." (Centre for Community Enterprise, 2000), or: "The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure." (United Nations, 2004). Through developping a recovering system where the combination of social, ecological and economical experiencing increases stress as a result of unpredictable change in environment, resilience describes individual and social systems property to face a catastrophic change by resisting, adapting or transforming (Walker & al., 2004; Holling 2001, Scheffer & al. 2003). In other words, community resilience describes the ability and capacity to deal with and adapt to changing conditions and continue to develop after a shock. Thus, resilience unveils the ability of the social system or community to increase its capacity for learning from past disasters for better future protection. For this to happen, governments, private industries and organisations, formal and informal structures, and individuals all have a role to play in the process, by identifying, developing and retaining the essential ingredients of resilience, in terms of sustainable development capitals.

2. Resilience and development capitals

Commonly, the three kinds of development capitals can be declined as:

- *social-cultural capital.* Pierre Bourdieu defines Social Capital as « the sum of resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition » (Bourdieu & al, 1992). In this acceptance, social capital shares a productive dimension with the economical system : « Social capital is defined by its function. Like other forms of capital, social capital is productive, making possible the achievement of certain ends that would not be attainable in its absence » (Coleman, 1990). In this way, social capital manifestation includes norms and values which facilitate exchanges, reduce information and transaction cost, permits trade in the absence of contracts, encourage citizenship responsibility, and, therefore, the collective management of resources (Fukuyama, 1995). This notion incorporates social shared values as knowledge, skills, attachments, cultural knowledge, education, training, co-operation networks, shared trusts and values of the population. Social capital is thus treated as a mediating variable, shaped by public and private institutions, which strategy combination has important impacts of development outcomes. It can also be a powertrade for cooperative action, through policies participation or collaborative intelligence at a territorial level: « social capital refers to features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating coordinated actions » (Putnam 1993).

- *economical capital.* It is sometimes separately considered as *financial* capital, which refers to the funds that are available to individuals and groups in a community. This form of capital can generate a flow of income to support the holder's immediate wellbeing, such as money, machinery and infrastructure providing physical assets of businesses and households, as well as public or community physical infrastructures. Community wellbeing is then produced by converting *stocks* ("inputs") to "outputs" such as *flows* of services; *economical capital* can also be converted into some other form of capital contributing to community wellbeing.

- *ecological (organic) capital.* This recovers goods and services items such as exploitation or transformation of natural resources, specific land-use and settlement patterns, biodiversity management, nature valuation, landscape preservation, sustainable farming and food production. Hence, the ecological stock represents objectified and accumulated labour (Bourdieu, 1990) and context-related knowledge describes the interrelations between natural resources and amenity production: in one word, effective adjustments in land-use to reconnect nature with society (Swagemakers, 2008). As neo-classical economics stated a separate organisation from environment and a total freedom from biophysical constraints, economical think-tank interested with natural resources and environment introduced *ecological (organic) capital* notion to refeer to the limited natural resources stocks, through considering economy as an open-growing totally dependant subsystem of a closed, non-growing finite ecosphere system. Thus, ecological capital dimensioning introduce a highly-ordered dynamic system governed by the second law of thermodynamics, its entropy being directly in- and out-putting to ecosphere energy/matter equilibrium (Rees 2003).

3. Stocks and flows modelling

Those three kinds of capital, when combined, generate a wide range of "outputs", or wellbeing attributes, that are important in terms of community valuation. As a complex combination between economic, environmental and social life values, outputs that people may need or seek in order to maintain their wellbeing involve complex forms of capital that are the result of joined eco/socio/environmental inputs. So, communities can be considered as complex systems that provide economic, social-cultural, and environmental goods and services that contribute to societal amenities, produced by converting *stocks* of various forms of *capital ("inputs")* into *flows* of services, or common amenity attributes *("outputs"*).

Therefore, a community resilience hypothesis can be defined as a function of the capability to extent its available capitals in the three (social/ economical/ environmental) dimensions of sustainable development. A decline or absence in stocks of one type of capital may signal a resilience decrease. Alternatively, large or growing stocks of capital may act as a buffer against forces that test a community's ability to cope with change. Some forms of capital might be emerging while others become obsolete, so that equibrium vector between those social, economic, environmental capital dimensions is important for helping to determine practices and policies for the decision making and political directions to follow sustainability laws.

To enable good decision-making practices, sustainablility modelling should therefore evaluate these previous capitals circulation structure, through stock to flow transformation characterization during production/ consuption/ exchange processes between economy, society and environment.

In the study of energy systems, the two first elementary concepts, potential energy and energy dissipation constitute the physical analogical counterparts of stock and flow generation into development process. Moreover, stocks of a community's capital ability to generate flows of community wellbeing is therefore modelled as an *induction process* of the community system, which physical counterpart corresponds to the inertial concept of energy systems, *kinetic energy*. Those physical properties are known as "passive components" of the corresponding mechanical/electronical systems. This analogy was first inspired by a well-known late 80's model of socio-economic crack-up, known as "Silent Weapons for Quiet Wars", which presents economy as a social extension of natural energy systems. This last, also named "E-model", is constituted by the three passive components, potential energy, kinetic energy, and energy dissipation, thus allowing economical data to be treated as a thermodynamical system (Cooper, 1991). To extend this model to social and ecological sustainability pillars, we propose to built an extended E(Economic)-S(Social)-O(Organic) model, based on those three components of sustainable development (Woloszyn & alii., 2012), as seen figure 1:

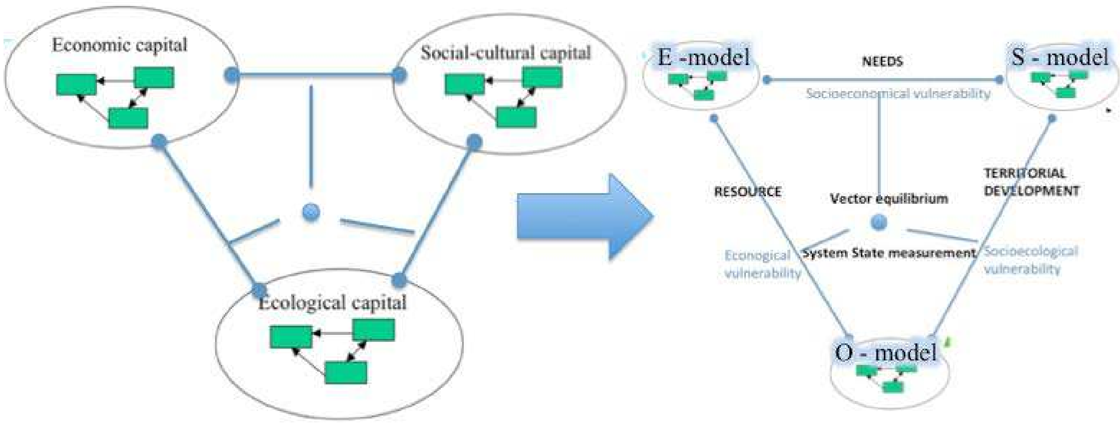

Fig 1: Articulation and convergences between sustainable development capitals and ESO model extension.

4. The E S O local/global transition paradigmatic model

In the science of physical mechanics, potential energy is associated with a physical property called elasticity or stiffness, and can be therefore represented by a stretched spring. In electronic science, potential energy is stored in a capacitor instead of a spring, which property is called capacitance. Second passive component, kinetic energy, is associated with a physical property called inertia or mass, and can be represented by a flywheel in motion. In electronic science, kinetic energy is stored in an inductor, a magnetic field, which property is called inductance. Endly, energy dissipation is associated with a physical property called friction or resistance, thus converting energy into heat.

As E-Model assumes that economics can be considered as social extension of a natural energy system, also constituted by its three passive components, Social and Ecological pillars could therefore be defined as subsystems based on those three previous passive components understood as capitals dynamics, thus constituting the global open sustainability model.

By converting capital stocks into service flows in the 3 dimensions of sustainable development, stocks are understood as constitutive of the "capacitance" property of the system, as "flows" constitute its conductance, leading to capital stocks growing or declining. This system evolution describes the "inductive" effect of the (stock/flow) conversion process. As a consequence, association of potential, dissipative and kinetic energy concepts with the three pillars of sustainable development leads us to define the three dynamical notions of a general theory of social-eco-environmental entropy, also called "generalized social energy": capacitance, conductance and inductance. Thus, sustainable co-evolution of environmentalized systems answer to those complementary potential, dissipative and cinetic processes constitute the ESO IT collaborative model (Dumas-Woloszyn 2012), involving economic inductance, social inductance and ecologic inductance as illustrated figure 2:

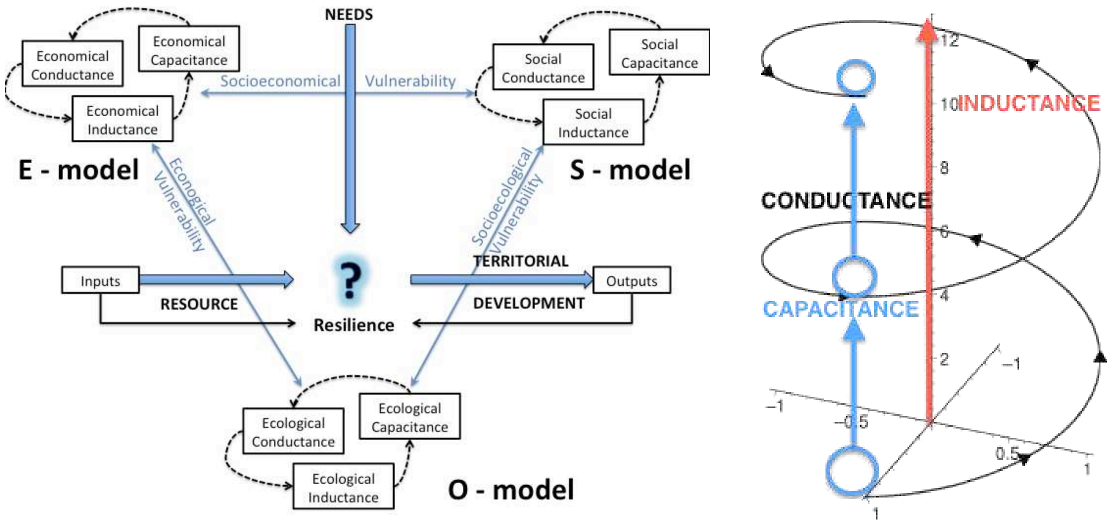

Fig 2: Open-analogical model of sustainability and inertial inductance behaviour

Economic inductance, constitutive of the " E-Model Silent Weapon", can be understood as an analogy with an electrical inductor: this last has an electric current as its primary phenomenon and a magnetic field as its secondary phenomenon. Analogic view of this process describes an economic inductor as a complex flow driving, constituted by economic value as its primary phenomenon and population behavior as its secondary field phenomenon of inertia. Social Inductance (S-Model) considers social implying cooperation action as primary phenomenon and environmental integration process as secondary field phenomenon. Last but not least, ecologic/organic Inductance (O-Model) implies ecological management as primary phenomenon and ecosystemic interactions between air (athmosphere), water (hydrosphere), ground (litosphere) and life (biosphere), or environmental benefits/losts, as secondary inertial field phenomenon.

A further description of those passive components is given following figure 3:

Property (Entropy class)	**Economical (Model E)**	**Social (Model S)**	**Ecological (Model O)**
Capacitance (Potential)	Capital (stocks) Compétences Confiance	Cultures, Social capital (actors & networks…)	Biosphère (Biotope +biomasse) Etat d'être (bien-, mal-)
Conductance (Dissipative)	Flux (Goods) Services production	Networking Cultural action Cooperation	Eco-actions Gestion environnementale (Ecological management)
Inductance (Kynetical) (= variation capacitance)	Resultance (valeur ajoutée, retranchée…)	Integration - différenciation Radicalisation	Ecosystemic interactions Fertilisation Désertification

Fig 3: The three passive components of the sustainability pillars

Thus, this analogy identifies the "stock" as the capacitive property of the system to maintain or develop its capital, the "flow" as the conductance processes of capital production, and the "benefit" (or loss) of the system driving as the inductance effect of stock to flow capital recovering. During the "flows" motions, inductance supplies to both capacitance and conductance, with taking into account the systems transformation potential through their temporal activities. This paradigmatic change of the process leads us to consider a thermodynamic approach of open-living systems, instead of mechanical-closed systems: stability key of those lasts closed systems, retro-action, is here considered as the open-systems evolution source.

When a community's capital stocks is growing, its capacity to generate flows of goods and services will also grow, thus enabling the community's ability to improve its wellbeing in the future, or consolidate its resilience capability. As a consequence, *induction* of the socio-eco-environmental system depends on the community's capital *stocks* capacity to generate *flows* of community wellbeing. This can be designed as a non-linear retro-active effect of community flow generation. As an illustration of this retroaction process, (Hicks, 1939) stated that maintenance of the wellbeing of a community was a function of income *flow* maintenance, the conductance process, from a done *stock* of capital, the community capacitance. The question of defining the *stocks* of a community's capital that generate enough *flows* for community wellbeing provides here an econologic view of resilience: a rise (or fall) in a community's wellbeing can be explained by increases (or decreases) in its stocks of capital. In case of disfunction between capacitance level and conductance process, inductance should exceed capacitance, and a leading power factor is produced, driving community to uncontrolled economic/social flows driving. This induced effect generared the 2008's crisis, due tu excessive financial flows resulting from american subprimes system, which has led to a "savage" inductance process, traduced by financial crash & social crisis. Harmonic problems of eco/socio/environmental inductive interactions have then emerged, so that the dissipative system disrupted its equilibrium between the sustainable dimensions of the development process. Induction process has been also illustrated in 2012 U.S. drought event (Woloszyn 2012) as well as for indian population (Woloszyn & al. 2013) or french Coast natural hazard (Woloszyn & al. 2013b) resiliences.

5. Routes to viability

To achieve economical/sociocultural/ecological coefficients valuation, approach of this ”Triple bottom line” structure of sustainability, understood here as three inter-related systems, imply informational dimensioning of: (1): Economical macro and microeconomic dynamics (Akerlof 2002, Stiglitz and al. 1992), (2): Population-wealth distribution (Wolff 2007, Davies and alii., 2007), and (3): Ecological human footprints (Ayres 2000, Costanza 2000, and Rees 1992). Each of those described subsystems, feeded (inputs) and feeded by (outputs) the two complementary sustainability pillars should enable to solve a viability criticity matrix of socio-ecological transition process. As System State measurement provides the mentioned coefficients in terms of vulnerability levels in the multidimensional (economical/sociocultural/ecological) evaluation system. Thus, action driving maintaining the system into sustainability limits, responding to E.S.O. criticity conditions, can be provided through a specific "Viability kernel" computational framework. This framework fosters operational definitions of resilience, vulnerability and adaptive capacity, thus helping to understand which response has to be brought to face environmental changes.

Assessing resilience within an economical-ecological-social system is becoming a challenge in the context of sustainable development. In this context, the mathematical theory of viability enable to study the compatibility of sustainability dynamical systems with "desirable" constraints (Aubin et al., 2011), defined by viability studies to provide efficient territorial control policies. When the system evolves outside the desirable constraint set, viability theory can assess whether and how the system can be driven back to desirable states.

6. Conclusion

The ability to preserve territorial identity in a changing environment is a indication of viability. Also a resilient system must have the ability to anticipate, perceive and respond in an environment of scarcity and pressure.

As a diagnosis key of resilience process, inductive requirements could be finded into politics and action skills. (Hollnagel, Woods & Leveson, 2006) claimed that this approach defines: “Resilience as a form of control: ... In order to be in control it is necessary to know what has happened (the past), what happens (the present) and what may happen (the future), as well as knowing what to do and having the required resources to do it...”. Processes control, including ability to absorb perturbations and adaptation appears to be a way to understand resilience and viability. Such a resilient and viable system, able to resume a steady state after it has been disturbed in a way not envisioned by its designer, have been described by (Ashby, 1956) as an *ultra-stable homeostatic* system.

Thus, this viability framework gives indication on the possible consequences of a hazard or an environmental change, but also on the policies that can cope with the situation. Adaptive capacity as the reduction in a given vulnerability statistic due to the introduction of new policy options should then be achieved by the acknowledgement of the inductive process within the viability kernel decision space. Thus, Achieving sustainability goals through effective economic, social and ecological reforms as a route to the sustainability transition may propose societal anticipation and socio-cultural response to environmental constraints and shocks. To respond to this requirement, mathematical framework of viability theory fosters operational definitions of resilience, vulnerability and adaptive capacity, to help understanding which response one should bring to environmental changes. But this wil be part of another paper.

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